

How Commercial Space Can Enable Science and Vice Versa

*Emerging Commercial Suborbital Capabilities
Workshop*

September 7, 2011

*Webster Cash
University of Colorado*

The Opening Joke...

Technology Development at NASA is in Great Shape!

A Quick Answer:

Commercial Space Can Re-establish Scientists' Access to Space

“How can we have a space program if we cannot get into space?”

James Burch, Southwest Research Institute, March 2011

Science Can Drive Development of Commercial Space

We can be your best customer if allowed

Scientists Can Follow The Lead of Commercial

But commercial space has hardly started. Will explain.

Astrophysics

Will focus on what I know best as an example of a broader problem.

High Energy Astrophysics (X-ray Astronomy)

Black holes and other gee whiz science

The search for habitable planets and life on them.

Perhaps the most important piece of science/exploration on our table

But the lessons are broadly applicable

But First, How Is Astrophysics planned?

Decadal Reviews:

Every ten years by the National Academy of Sciences

The Community of Users

(mostly observers and theorists)

gets together and sets priorities for NASA and NSF

Effectively, this is a focus group of NASA's customers.

What The Customers Asked for in 2000

Large Missions

1. James Webb Space Telescope
2. Constellation-X
3. Terrestrial Planet Finder
4. SAFIR

Outcome

Started. Still being built
Studied 10 years, never started
Studied 10 years, never started
Largely ignored

Smaller Missions

1. Fermi (Gamma-Ray Telescope)
2. LISA (Gravity Wave Observatory)

Launched June, 2008
Studied 10 years, never started

...

What the Customers Asked for in 2010

Large Missions

Status

1. Finish James Webb Space Telescope
2. WFIRST
3. More Explorers
4. LISA
5. International X-ray Observatory (Con-X)

Still being built.
Probably won't be started
Will probably happen
Probably won't be started
Probably won't be started

Medium Efforts

1. New Worlds Technology Development

Assume something will happen
But nothing at 1 year mark

Outlook

It's bleak out there.

Space Science has largely ground to a halt.

and

JWST just came under fire from Congress for overruns

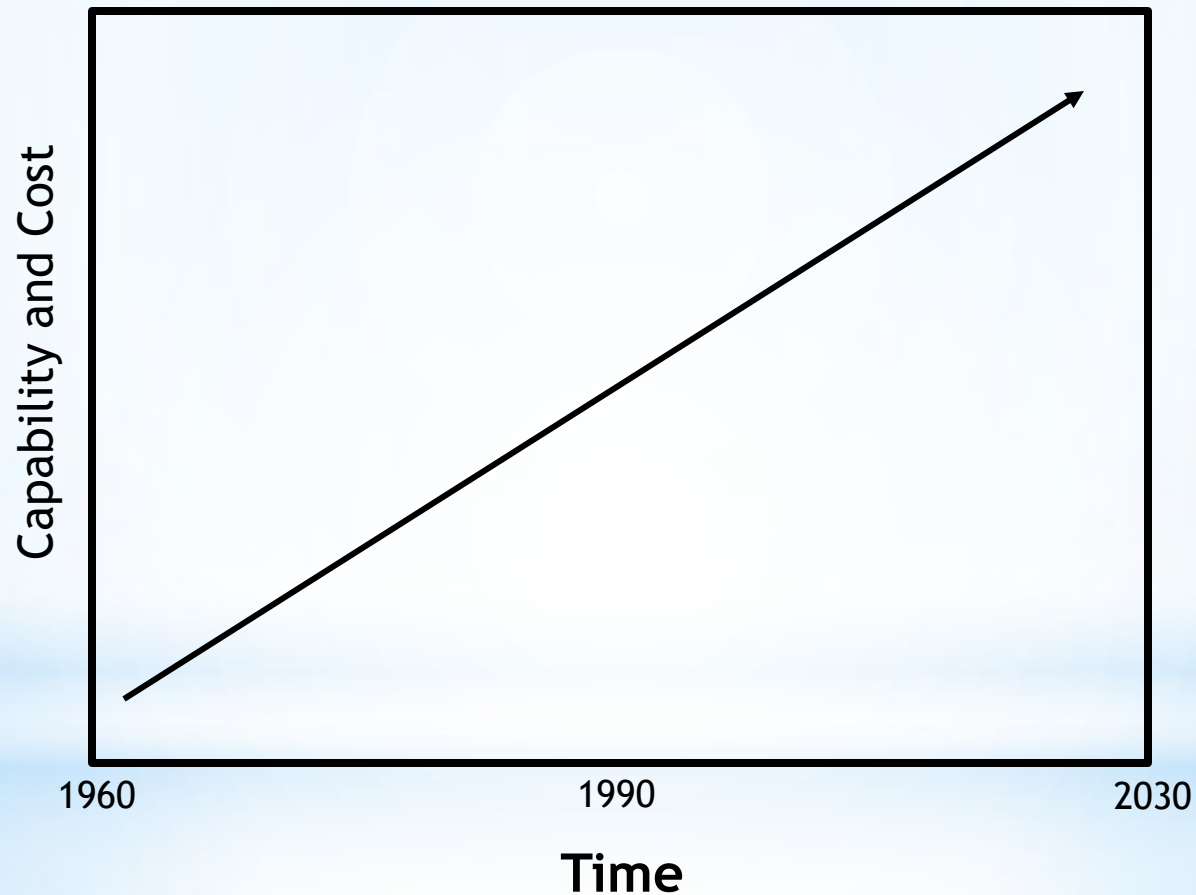
We are facing a no-win scenario: Our very own Kobayashi Maru

But like Midshipman Kirk, let's think outside the box.

The Trend Line

What's Driving this situation?

There is a relentless drive for more capability. Otherwise discoveries dry up.



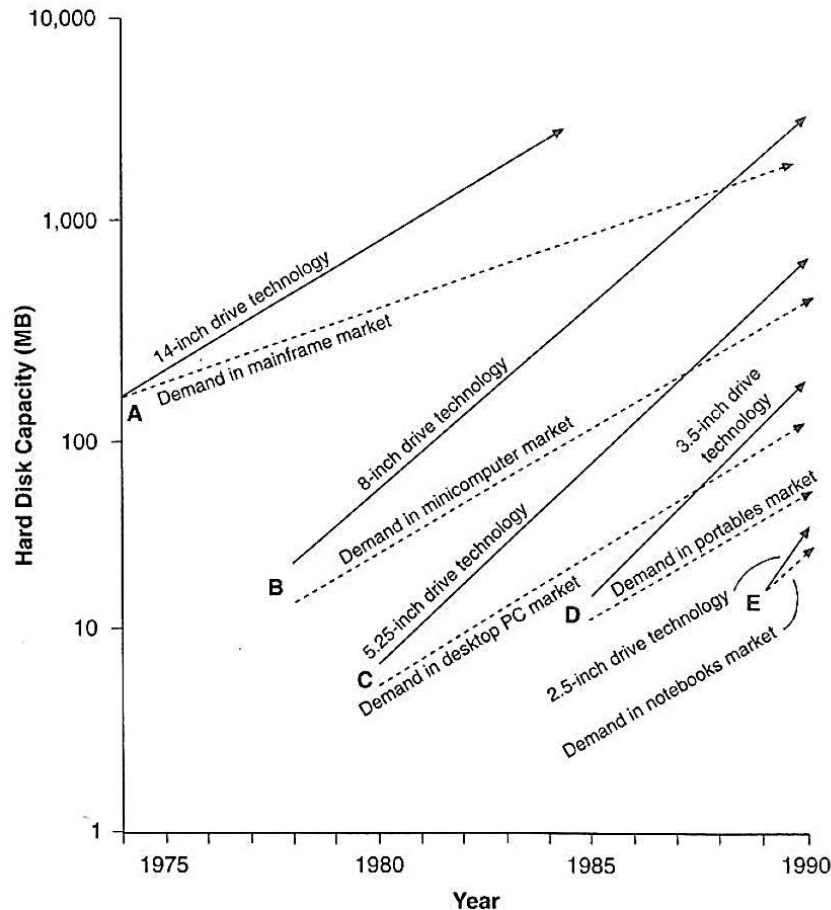
Well this happens in all high-tech fields and many low tech too.
What's to be done?

The Innovator's Dilemma

by Clayton M. Christensen
Harper Business Press, 2000

1 WHY GREAT COMPANIES CAN FAIL

Figure 1.7 Intersecting Trajectories of Capacity Demanded versus Capacity Supplied in Rigid Disk Drives



Thesis of the Book:

- Customers always want more of the same at lower cost.
- New Ideas are “Disruptive”
- Must start small and separate then grow
- Large companies adopt too late
- There is nothing companies can do to stop this cycle

Cycle of Disruptive Technologies

Quoted directly from Christensen's book:

1. Disruptive Technologies are first developed within established firms
2. Marketing personnel then seek reactions from their lead customers
3. Established firms then step up the pace of sustaining technology development
4. New companies are formed (often by frustrated engineers from established firms) and new markets for the disruptive technologies are found by trial and error
5. The entrants move upmarket
6. Established firms belatedly jump to the bandwagon to defend their customer base

Commercial Space is in steps 4-5

Space Science is in step 2-3

Let us look at the exoplanet situation from this perspective

NASA Centers Play the Role of the Great Companies

Navigator program 1998-present

Goal is to fly missions that can reveal Earths

Kept Developing SIM as Ground-Based Results Surpassed

Tried to improve Hubble-like telescopes to the needed level

Tried TPF-I -- Failed to get reasonable design -- dropped

Tried TPF-C -- 8m $\lambda/5000$ telescope Waaay too expensive

By 2004, Technology Development was clearly in trouble
(At least to those outside.)

The exoplanet problem

Earth is in there

The Basic Problem:

Stars are very bright and their glare makes it difficult to see fainter objects near them

A disruptive technology

We know the capability we want

We need to do spectroscopy of 30th magnitude planets
0.05 arcseconds from 5th magnitude star

That's a factor of 10 billion over half a Hubble resolution element!!!

Currently can do 10 thousand over 5 Hubble elements

We have a long way to go technically

Enter the disruptive technology:

In 2005 I invented new approach with help of
Northrop and Princeton

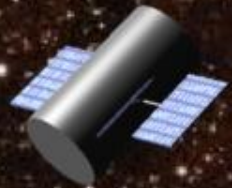
Support from NIAC -

A disruptive technology machine!

Cover of Nature, Patent



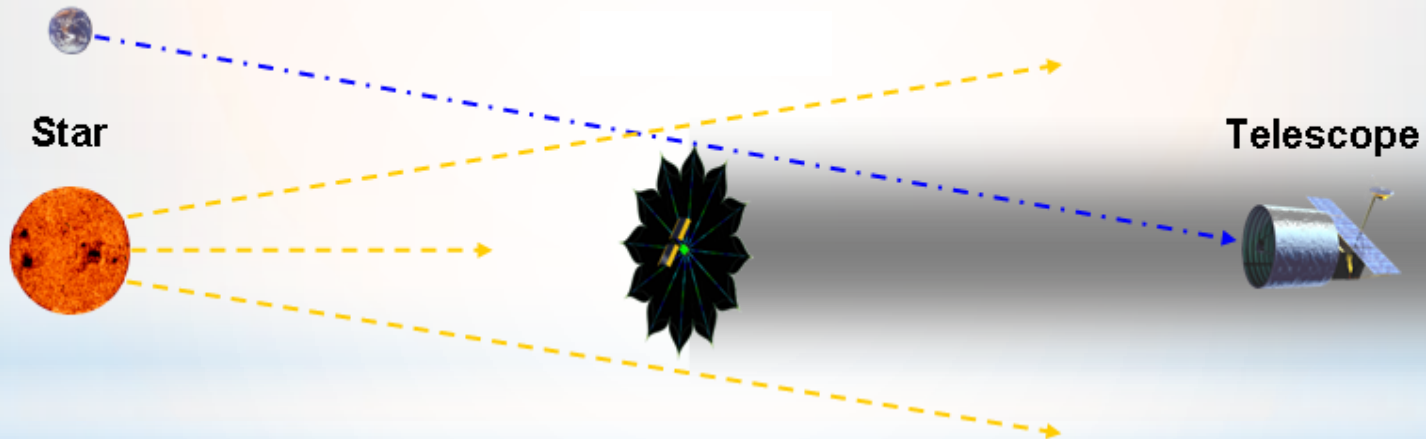
The New Worlds Observer



Starshade prevents starlight from entering the telescope

(where it causes havoc)

Exoplanet



But 100% of the planet light reaches the telescope

Starshade Critical Technology

Enabling Technologies

Precision Shape Control

- Maintain edge position
- Maintain structure shape

Thin Edge Treatment

- Maintain edge stability
- Minimize stray light

Precision Deployment

- Minimize jitter
- Maintain petal location

Opaque Membrane

- Maintain opacity
- Lightweight

2 Axes Formation Flying

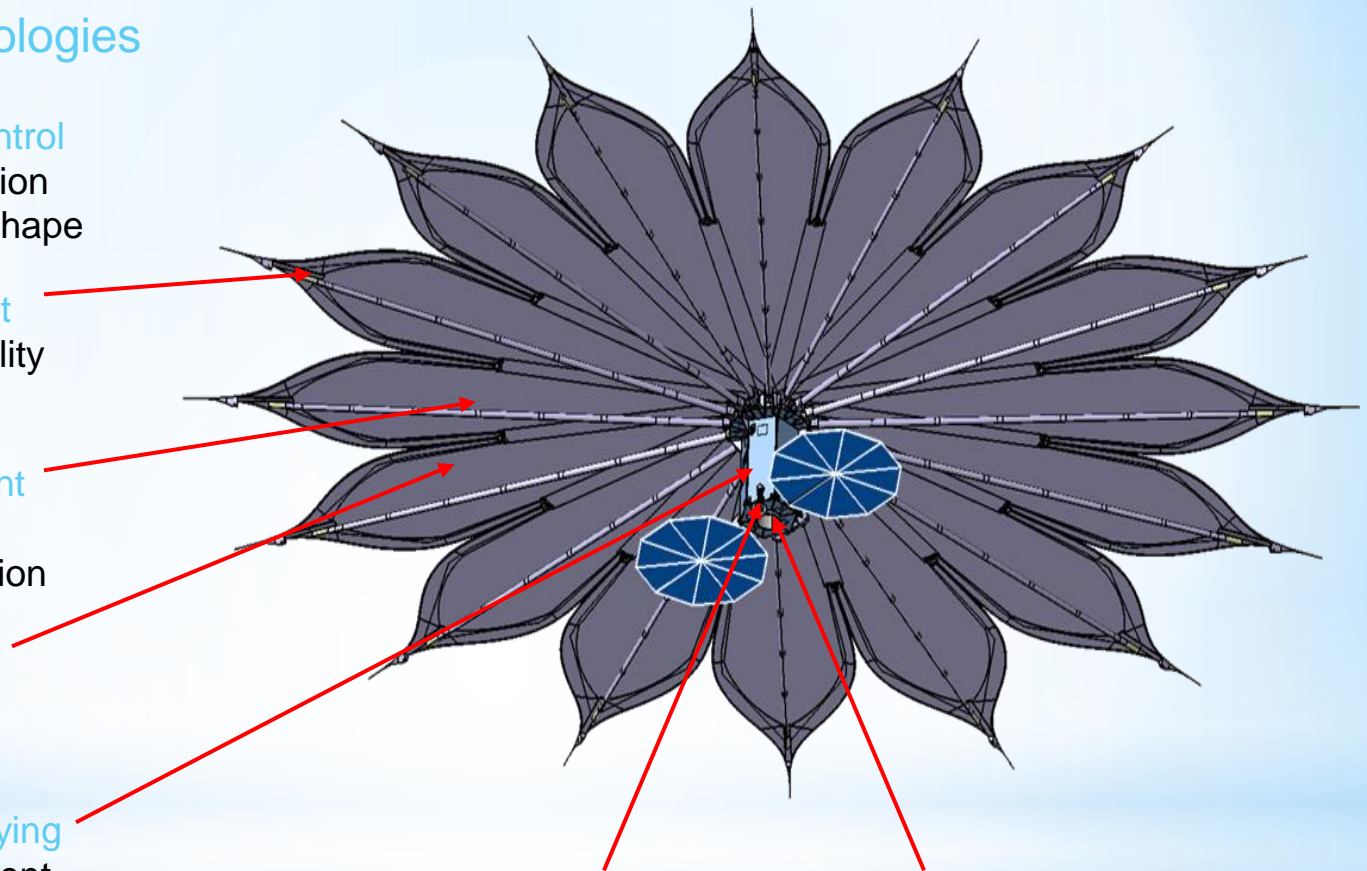
- Maintain 1m alignment
- Minimize jitter

Solar Electric Propulsion

- NEXT engine
- Increase observable targets
- Reduce propellant mass

Lightweight S/C Structures

- Increase observable targets
- Reduce overall mass



A frustrated scientist

- Two Architecture Study Proposals
 - Both funded (NIAC & Strategic Mission Concept)
- Nine proposals for technology development
 - All Rejected - I have zero funding
 - Only the vision of Ron Polidan and his group at Northrop has kept us in business
- New Worlds Technology Development Program
 - Number one medium cost program of the decadal
 - Specify coronagraphs and starshades be developed
- No plan for a year
 - In June, NASA's plan was revealed:
 - to continue what they have been doing

To Avoid Einstein's Definition of Insanity....

WE MUST DO SOMETHING DIFFERENT!!

BUT WHAT CAN WE DO?

The Only way to Develop a Disruptive Technology

Stress Demonstration

According to Christensen, one must start small and go after niche markets.

That means we must start actually using the new technology for its stated purpose - Astronomy.

DO NOT ATTEMPT TO COMPETE WITH FLAGSHIP MISSIONS

(there's a problem there because we are peer reviewed by the customer base, not our actual peers. We need to ask NASA to change that.)

What kind of niches can we address?

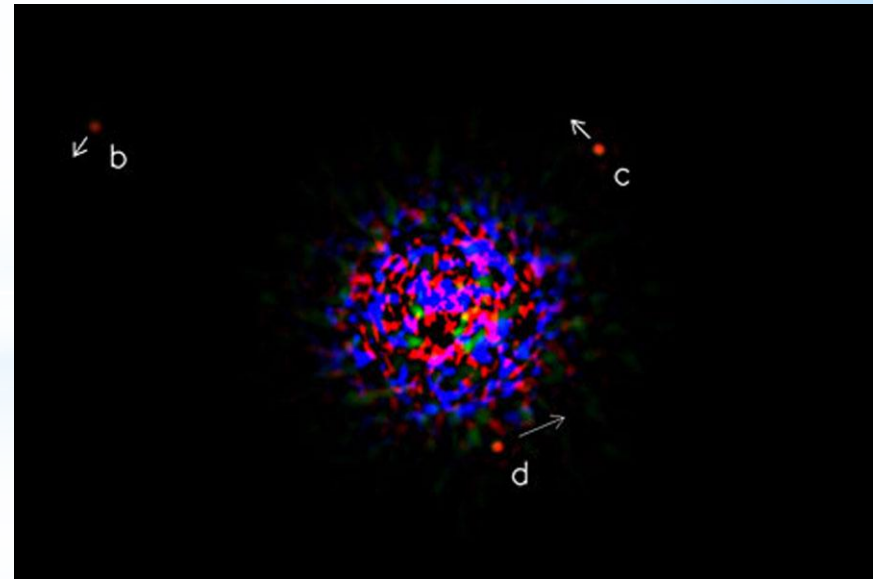
Exoplanets!

The community is seeing them already!



Fomalhaut
Seen with HST

HR 8799
From Ground Adaptive
Optic Telescope



Reductio Ad Absurdum

Full Up System	\$3Billion	Spectroscopy of Earths
Small System	\$500M	Study Outer Planetary Systems

Can we do anything without going into orbit?
(But separation is dropping as square of image quality requirement)

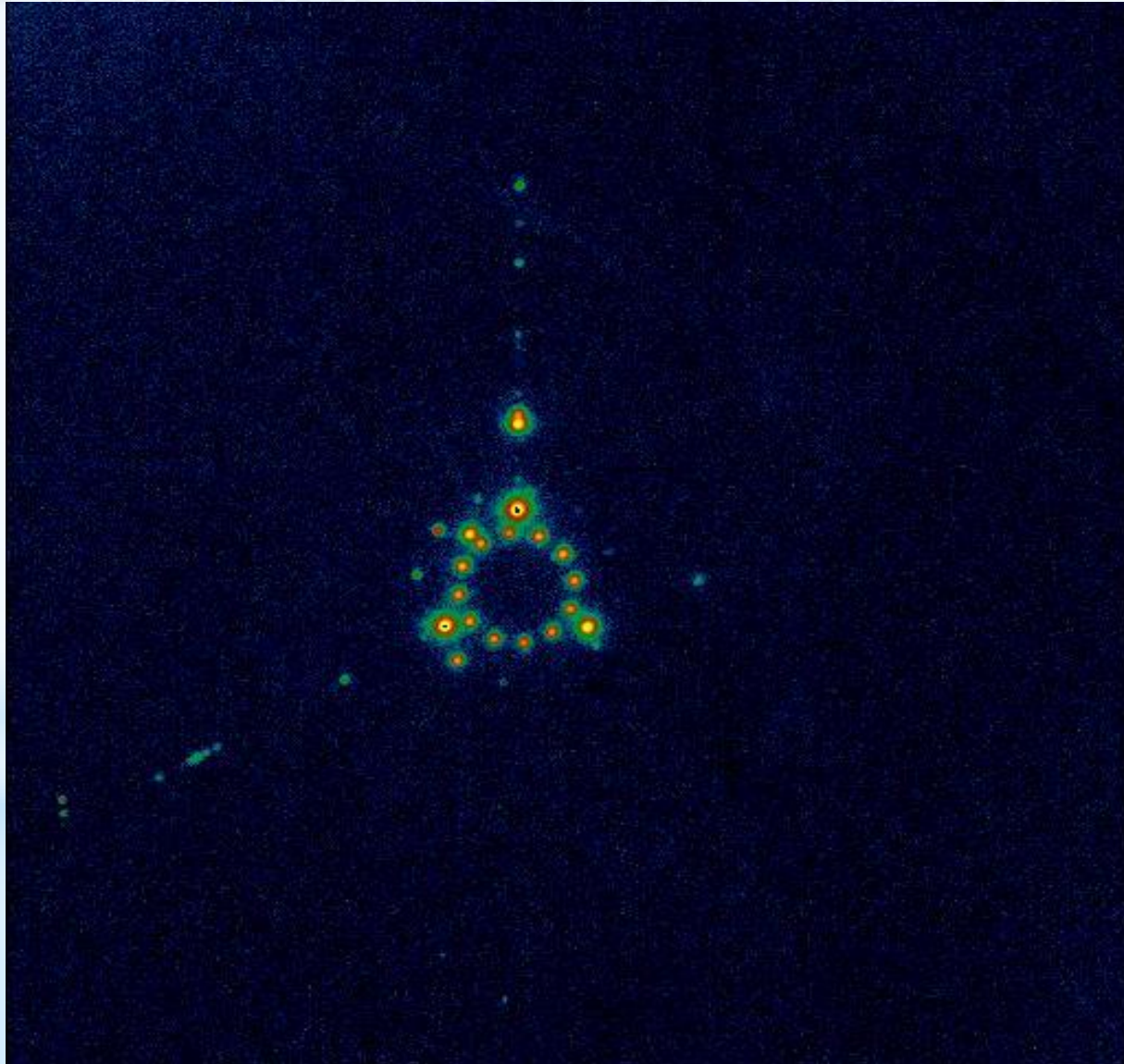
Suborbital System	\$20M	Nearest Stars Only
Ground	\$100k	Giant Debris Disks

Can we work in the atmosphere?
Actually, yes!!

Lab Tests	\$40k	Already Done
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We've deconstructed, now let's reconstruct.
Plan the move upmarket

Already working in the lab



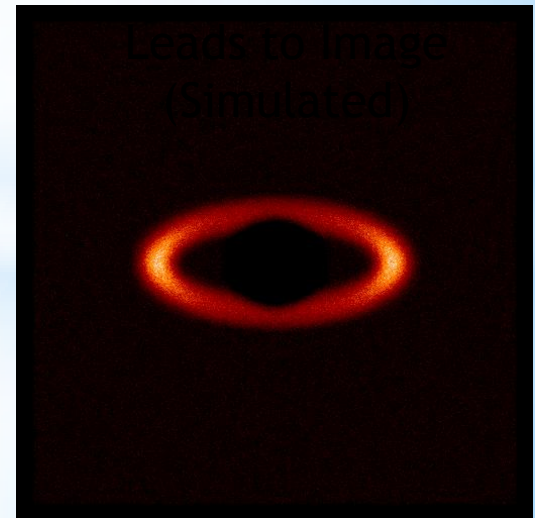
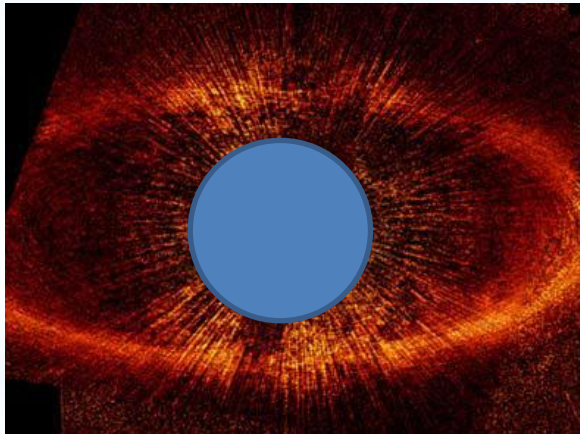
Must Do Astronomy

Find Market by trial and error
Debris fields - Not Earths



Small Starshade
On Frame

Starshade at 9km
On Mountaintop



Leads to Image
(Simulated)

We are doing this now.

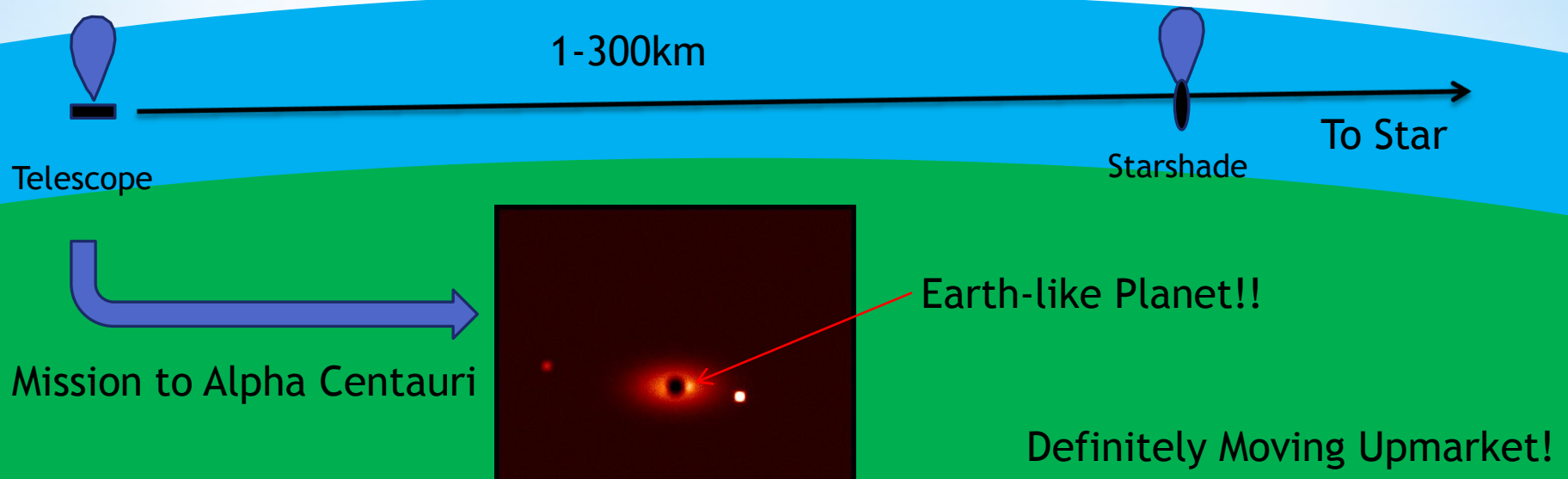
Next step: balloons and dirigibles

Balloons allow greater separation
and quieter atmosphere



Concept Have Been Developing
Submitted in March
Rejected three weeks ago

Two Balloons in Stratosphere
One is actually dirigible so it can hold position



Another Possibility Harness SRLV's

Masten XAERO Feb 16, 2011



How to harness an srlv

Proposed in February
Rejected in May

1 to 300km
altitude



Star



Starshade
On SRLV



Telescope

Still a big leap suborbital to flagship

We should fly low cost orbital mission

10m Shade, 0.5m telescope



Shows Zodiacal Light, Jupiter, Saturn

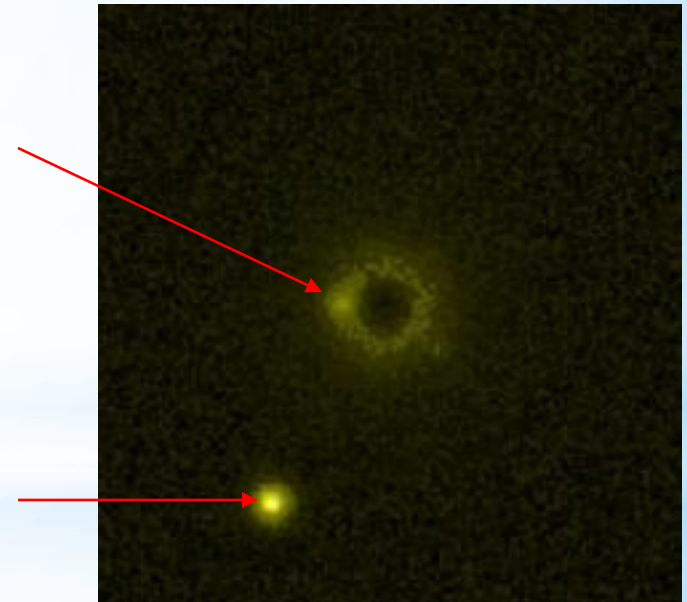
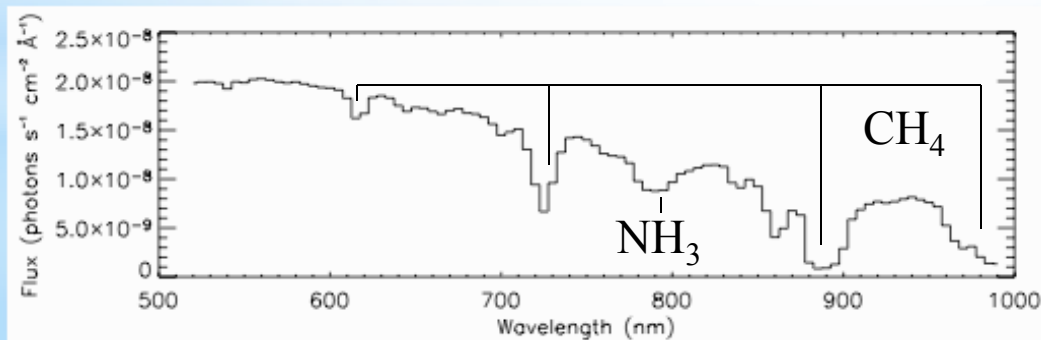
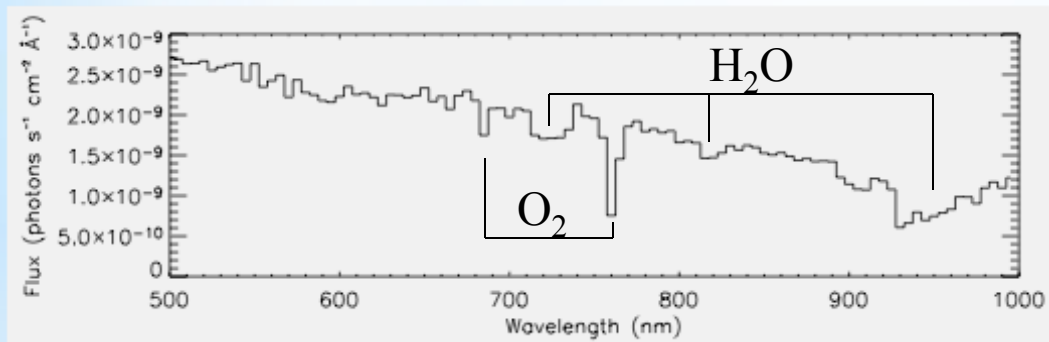
WE ARE NOW READY FOR PRIME TIME



Study Exoplanets

Perform spectroscopy of discovered planets

This will reveal their true natures



The 2020 decadal review

By 2020 we could have a slew of discoveries in the Astrophysical Journal

The 2020 Decadal review can pick it with confidence that

- It can be built

- It will not overrun

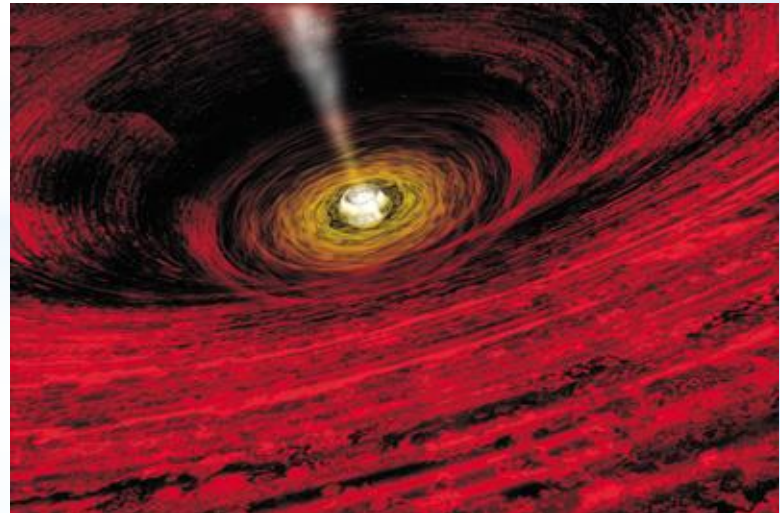
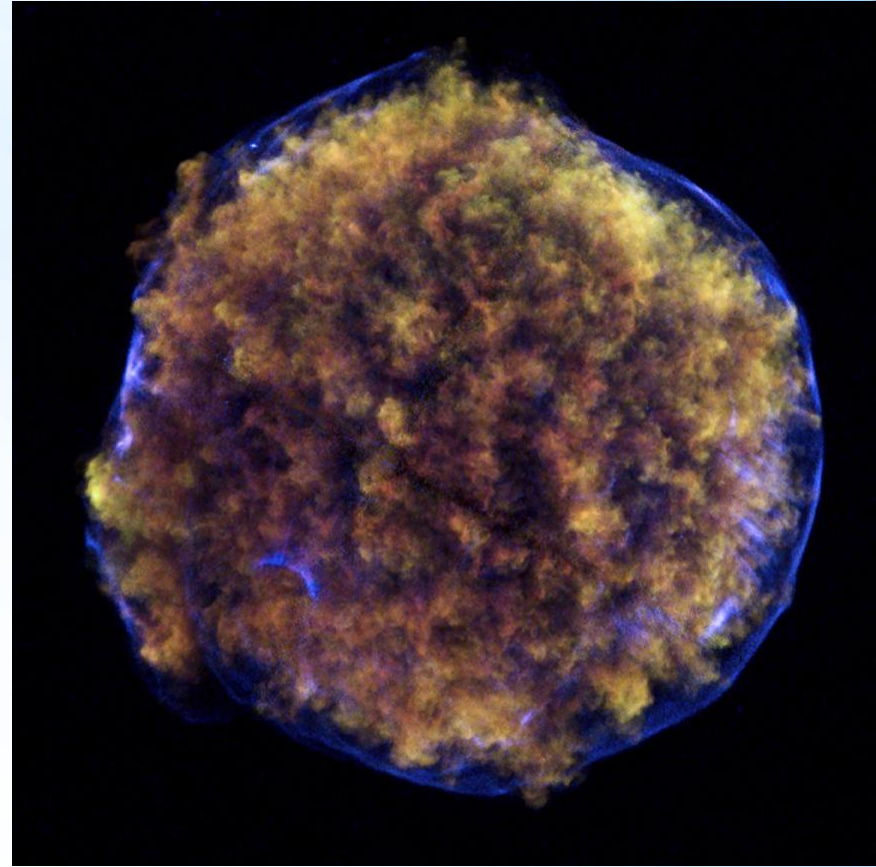
- Will achieve the astronomy goals

- That there is an experience base for the mission

The Disruptive Technology Will Have Won Over the Customers!

X-ray Astronomy

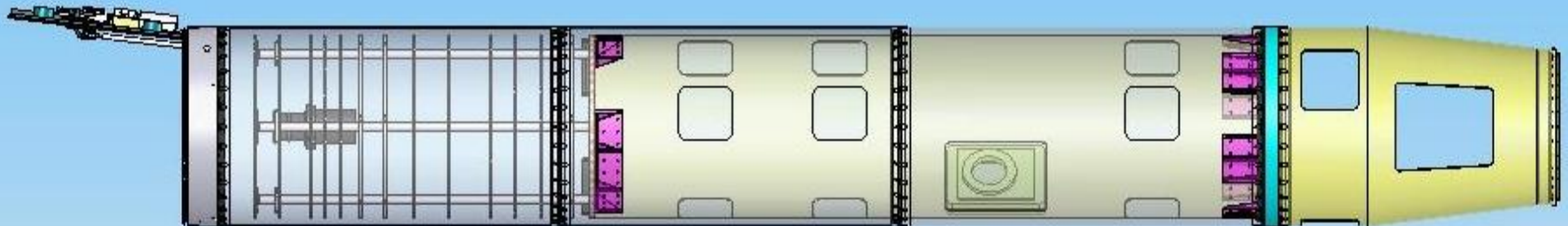
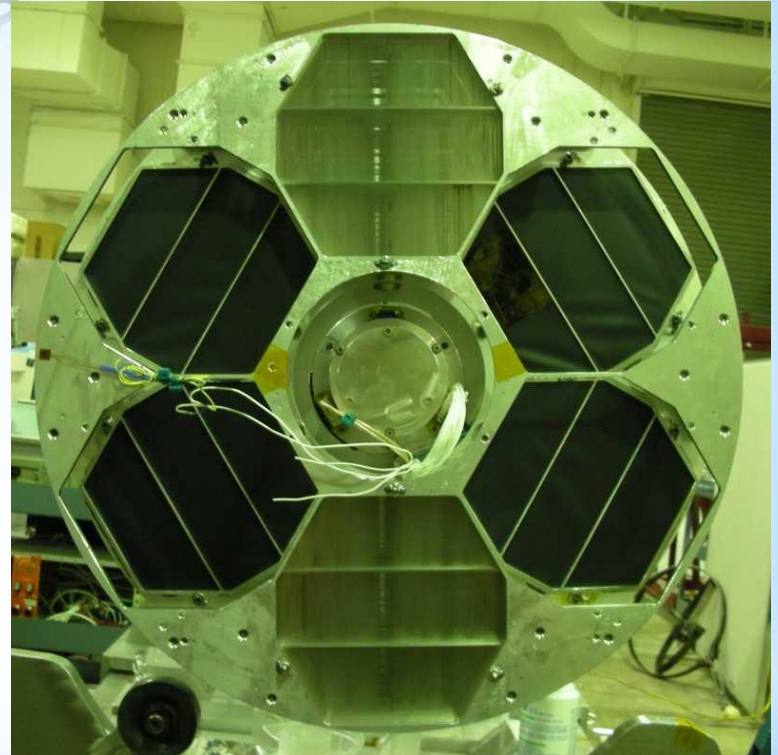
Two Small Explorers in the works
Flagship Cancelled
Future bleak when Chandra dies



A Similar Exercise in a different field: High Energy Astrophysics

Can anything be done suborbitally?

Yes. A few of us still are...



Last Launched November, 2009



Clearly XAERO is useable



Can do x-ray astronomy if
It can reach 150km

Repeat launches increase
observing time by order of magnitude



Reasons for Suborbital Science

- Essential for Developing Disruptive Technologies
- Experience Base
- Education
- Testing
- Demonstration
- Give Reason to New SRLV Capabilities

Back to Original Question: What Can Commercial Space Do For Science?

- Cheap access to space will allow us to develop the experience base
- New launch capabilities will support new science experiments
 - often in unexpected ways
- Break a path for developing “disruptive” technologies in space
- Science provides justification and impetus for new suborbital capabilities